

# Status of NHTSA's Ejection Mitigation Research

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# Ejection Mitigation

## Problem Definition

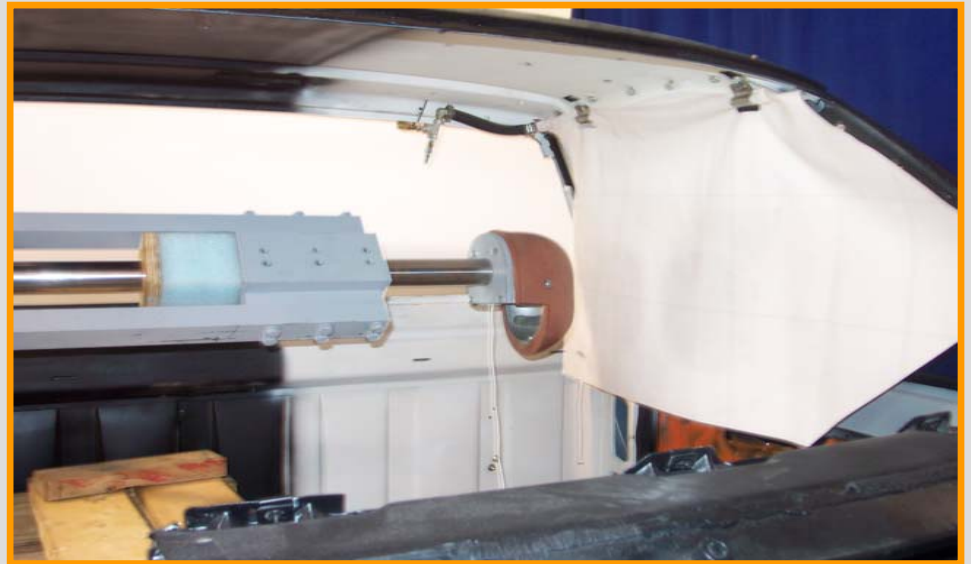
- **52,897 Annual Ejections (1995-2003)**
  - 1% of all crash-involved occupants
- **10,210 Annual Ejected Fatalities**
  - 32% of all fatalities
  - 6,124 through side windows
- **10,177 Annual Rollover Fatalities**
  - 3,703 ejected through side windows

# Ejection Mitigation Research Program Goals

- **Demonstrate Countermeasure Feasibility**
  - Evaluate ejection mitigation capability of prototype and current production systems
  - Evaluate injury-causing potential
- **Develop Occupant Retention Test**
  - Full-scale rollover tests not repeatable
- **Develop Rollover Sensor Performance Test**

# Ejection Mitigation Guided Impactor

- **18 kg Mass**
- **Featureless Headform**
  - Average of front & side of head geometries
  - More uniform shape
- **Measures Displacement**
- **Positioned Inside Vehicle**
- **Impact a Variety of Locations**



# Ejection Mitigation Systems Evaluated

- **Inflatable Systems**
  - Production Window Curtains
    - 2003 Lincoln Navigator
    - 2004 Volvo XC90
  - Advanced Head Protection Curtain (AHPC)
    - Zodiac Automotive US
- **Inflatable/Laminated Glazing Combination**
  - 2003 Lincoln Navigator (front only)
  - 2004 Volvo XC90

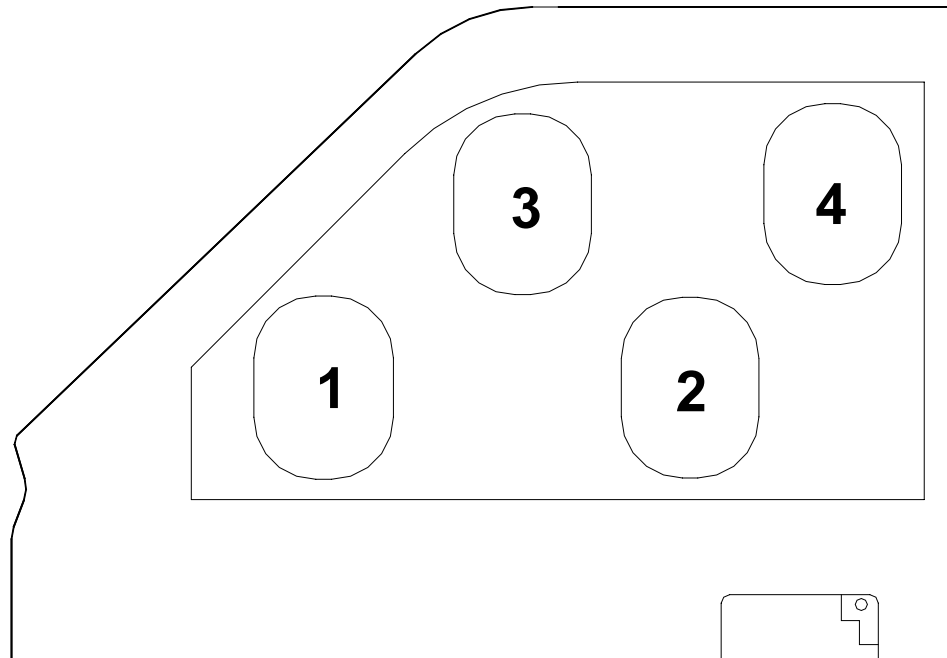


# Ejection Mitigation Pre-Broken Glazing



# Ejection Mitigation

## Front Side Window Impact Locations



# Ejection Mitigation

## Guided Impactor Test Matrix – Front Side Windows

Impactor Deflection Beyond Window Plane (mm)	Impact Location on Side Window Area											
	1			2			3			4		
	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec	16 kmph 6 sec	20 kmph 1.5 sec	24 kmph 1.5 sec
Lincoln Navigator (Open Window)	243*			74	186* 196*		211*	229*		-30	-37	-22
Lincoln Navigator With Side Laminate (pre-broken)	157			-14	6	35	137					
Volvo XC90 (Open Window)	154 167	163		93 52	84 107	193*	78	131 107	130	-22	-3	18
Volvo XC90 With Side Laminate (pre-broken)	58 105 86	102 151		26	27	44	59	97	118			15
Zodiac AHPC (Open Window)	135	122	150 143	49	38	54	81 78	76 81	96 102	-0.2	-9 -0.89	24 21
Zodiac AHPC With Side Laminate (pre-broken)	104						70		97 91			

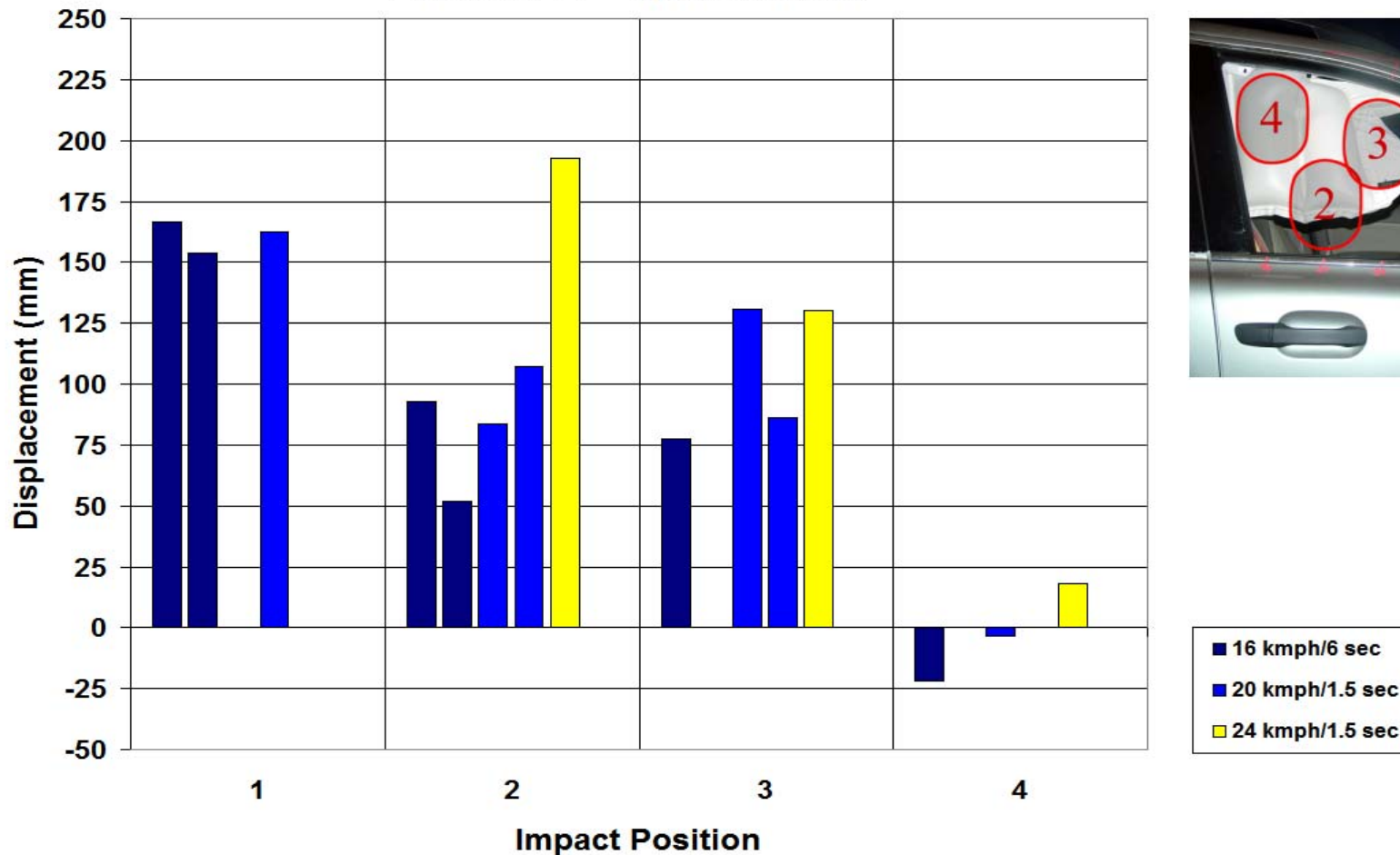
\* Impactor reached physical stops



# Ejection Mitigation

## Impactor Results – Front Window

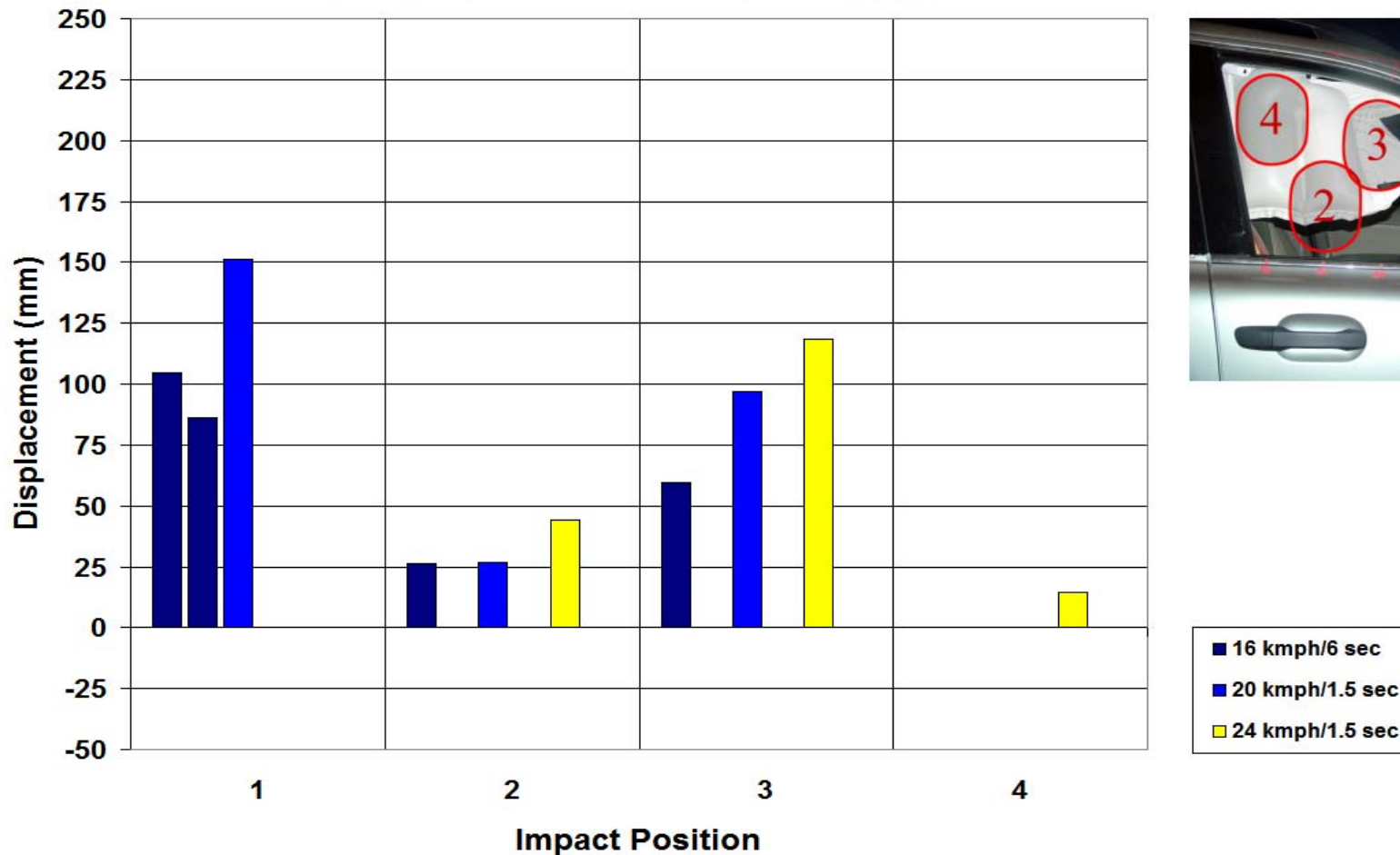
Maximum Excursion Beyond Window Plane  
Volvo XC90 - Open Window



# Ejection Mitigation

## Impactor Results – Front Window

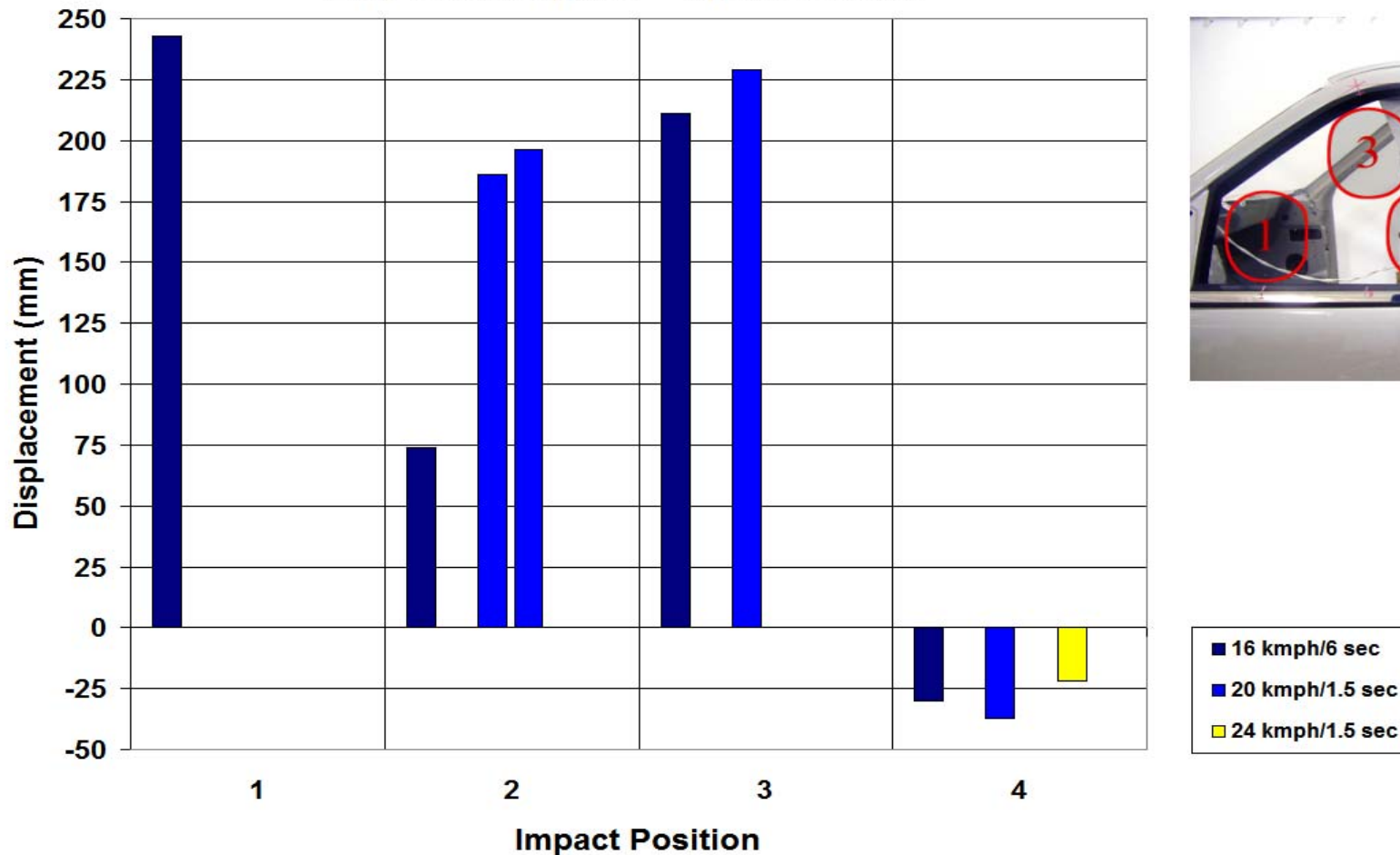
**Maximum Excursion Beyond Window Plane**  
**Volvo XC90 - Pre-Broken Side Laminates**



# Ejection Mitigation

## Impactor Results – Front Window

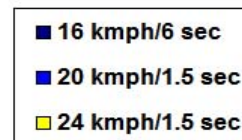
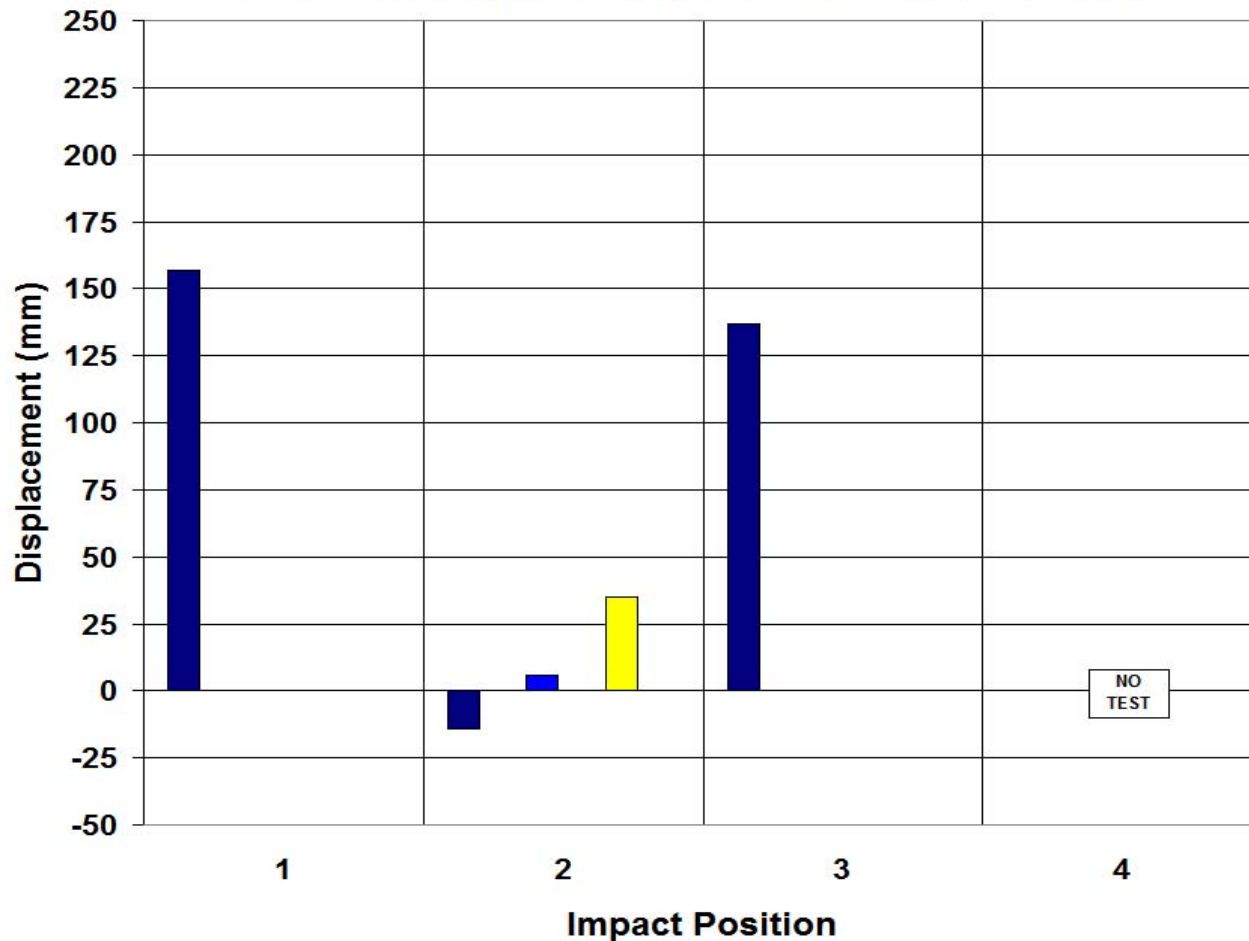
Maximum Excursion Beyond Window Plane  
Lincoln Navigator - Open Window



# Ejection Mitigation

## Impactor Results – Front Window

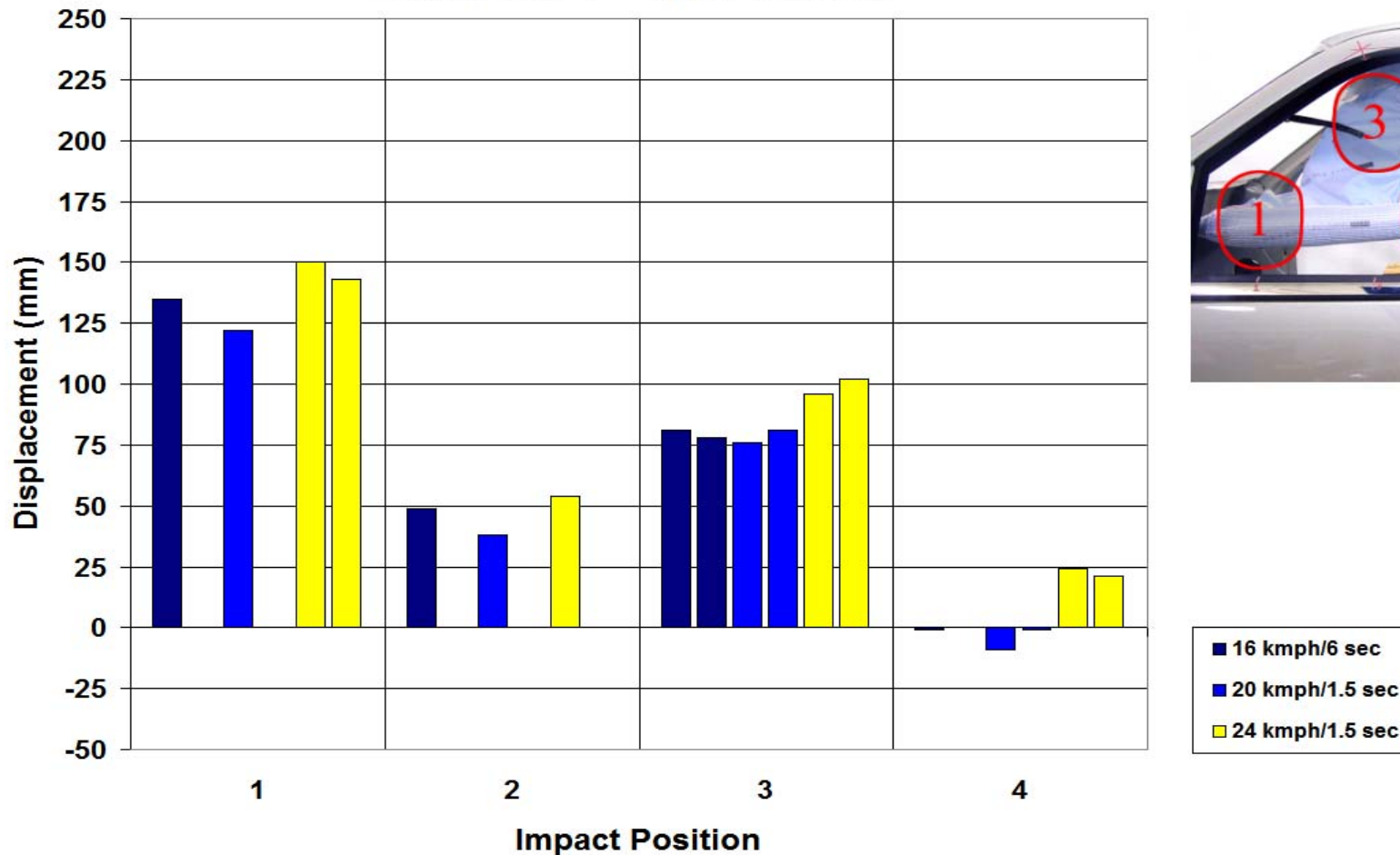
**Maximum Excursion Beyond Window Plane  
Lincoln Navigator - Pre-Broken Side Laminates**



# Ejection Mitigation

## Impactor Results – Front Window

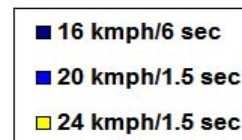
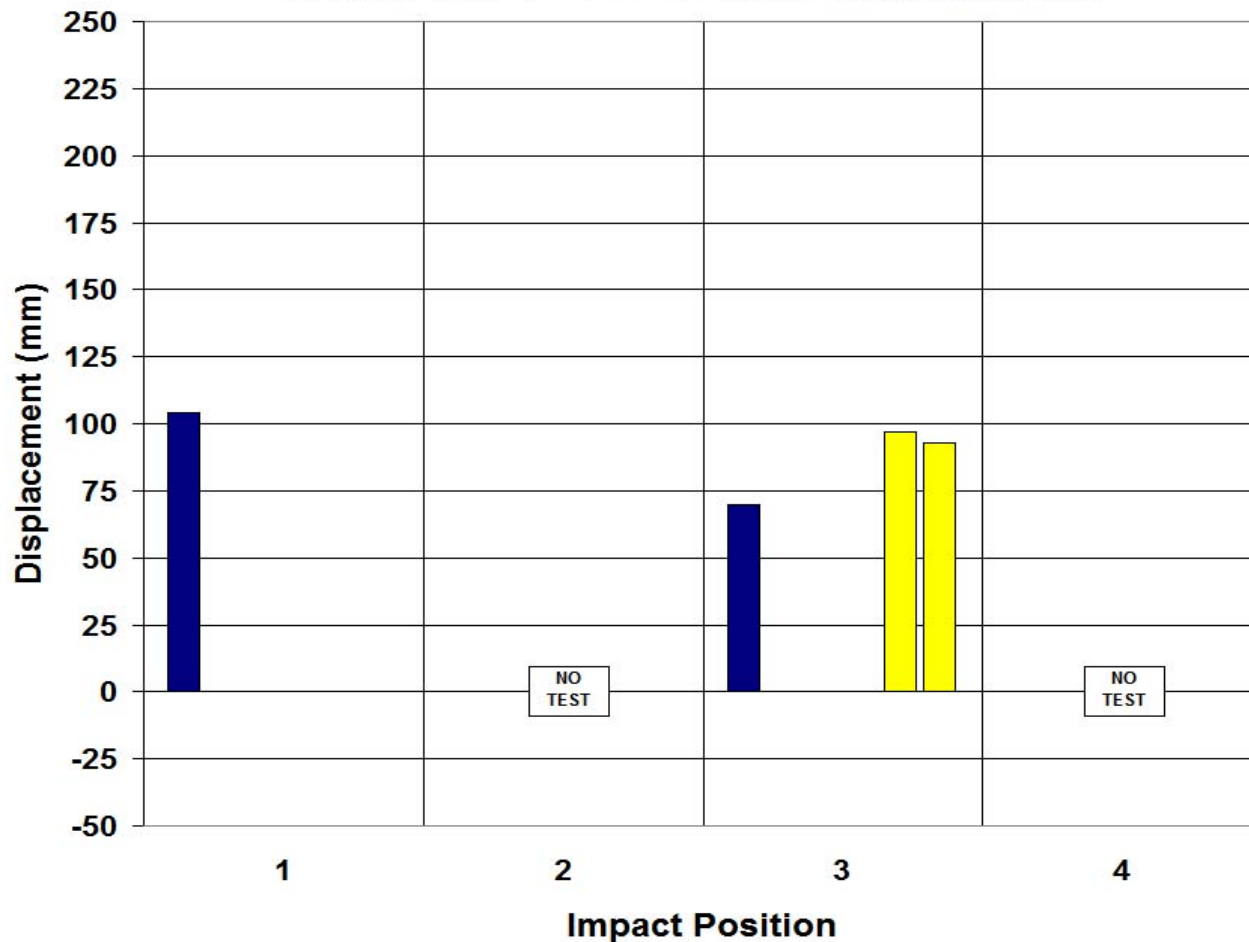
Maximum Excursion Beyond Window Plane  
Zodiac AHPC - Open Window



# Ejection Mitigation

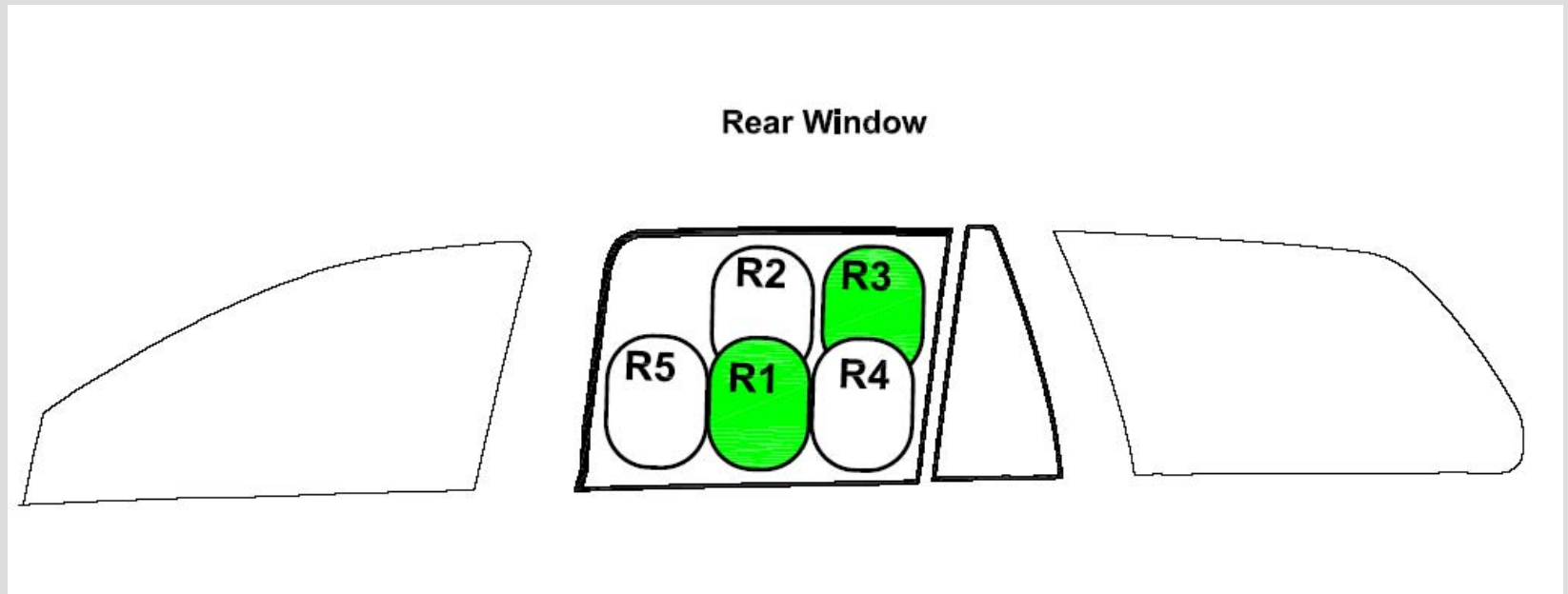
## Impactor Results – Front Window

Maximum Excursion Beyond Window Plane  
Zodiac AHPC - Pre-Broken Side Laminates



# Ejection Mitigation

## Rear Side Window Impact Locations



# Ejection Mitigation

## Guided Impactor Test Matrix – Rear Side Windows

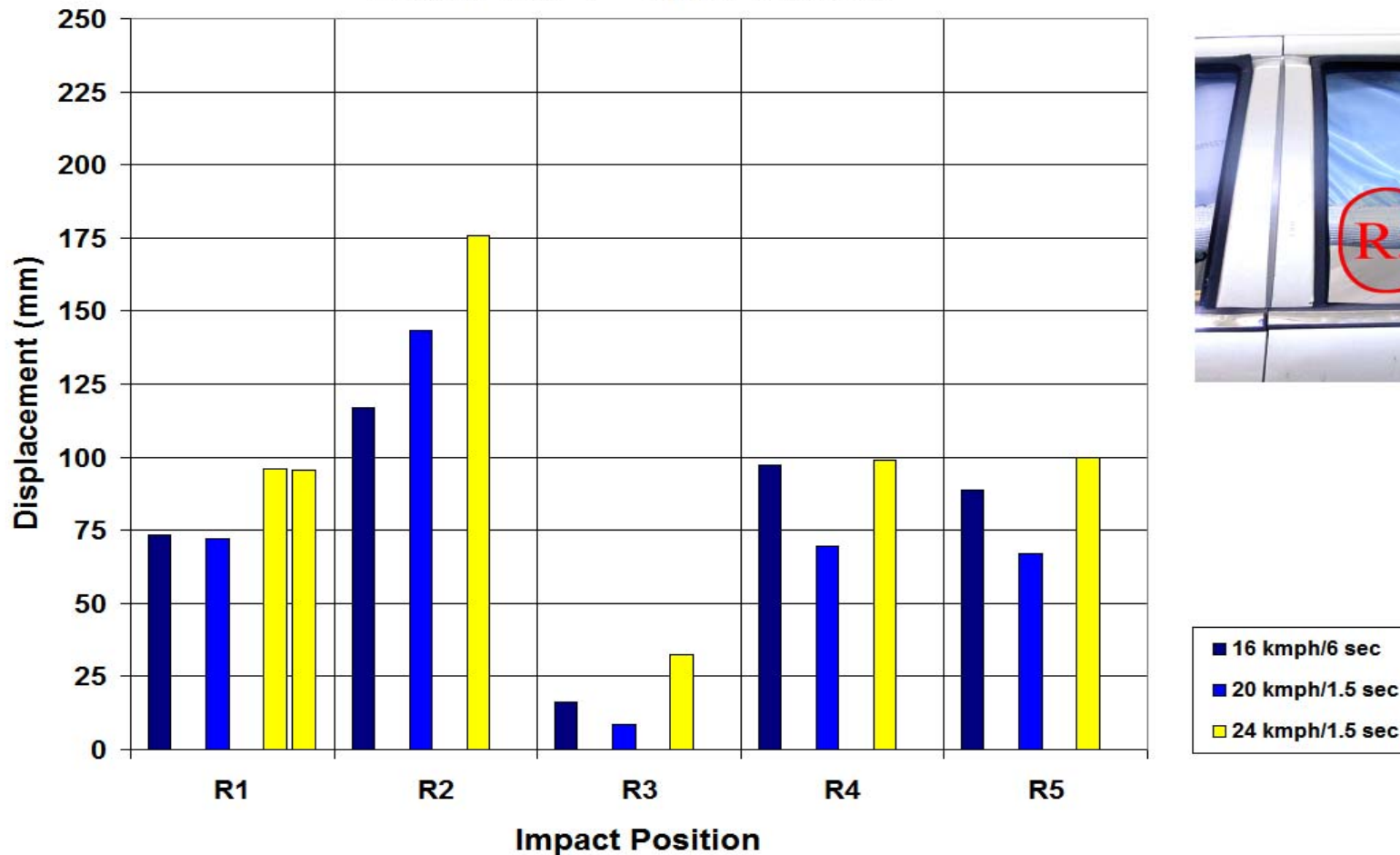
	Impact Location on Rear Side Window Area														
	R1			R2			R3			R4			R5		
	16 Kmph	20 Kmph	24 Kmph	16 Kmph	20 Kmph	24 Kmph	16 Kmph	20 Kmph	24 Kmph	16 Kmph	20 Kmph	24 Kmph	16 Kmph	20 Kmph	24 Kmph
	6 sec	1.5 sec	1.5 sec	6 sec	1.5 sec	1.5 sec	6 sec	1.5 sec	1.5 sec	6 sec	1.5 sec	1.5 sec	6 sec	1.5 sec	1.5 sec
Volvo XC90 Air Curtain	189	183					29		69						
Volvo XC90 Air Curtain & Broken Glazing	63	94	91 93				9		62						
Lincoln Navigator (Open Window)	136	318*	318*				-27	-14	40						
Zodiac AHPC (Open Window)	73	72	96 96	117	144	176	16	9	32	98	70	99	89	67	100

\* Impactor reached physical stops



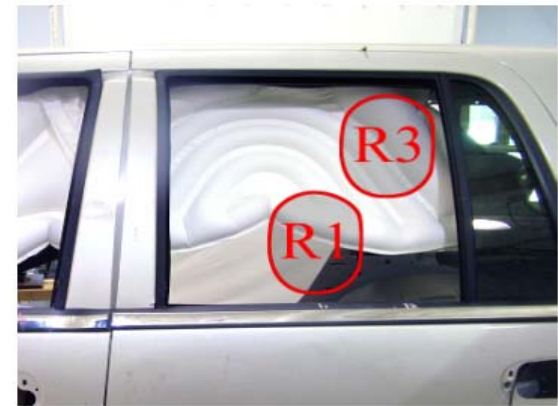
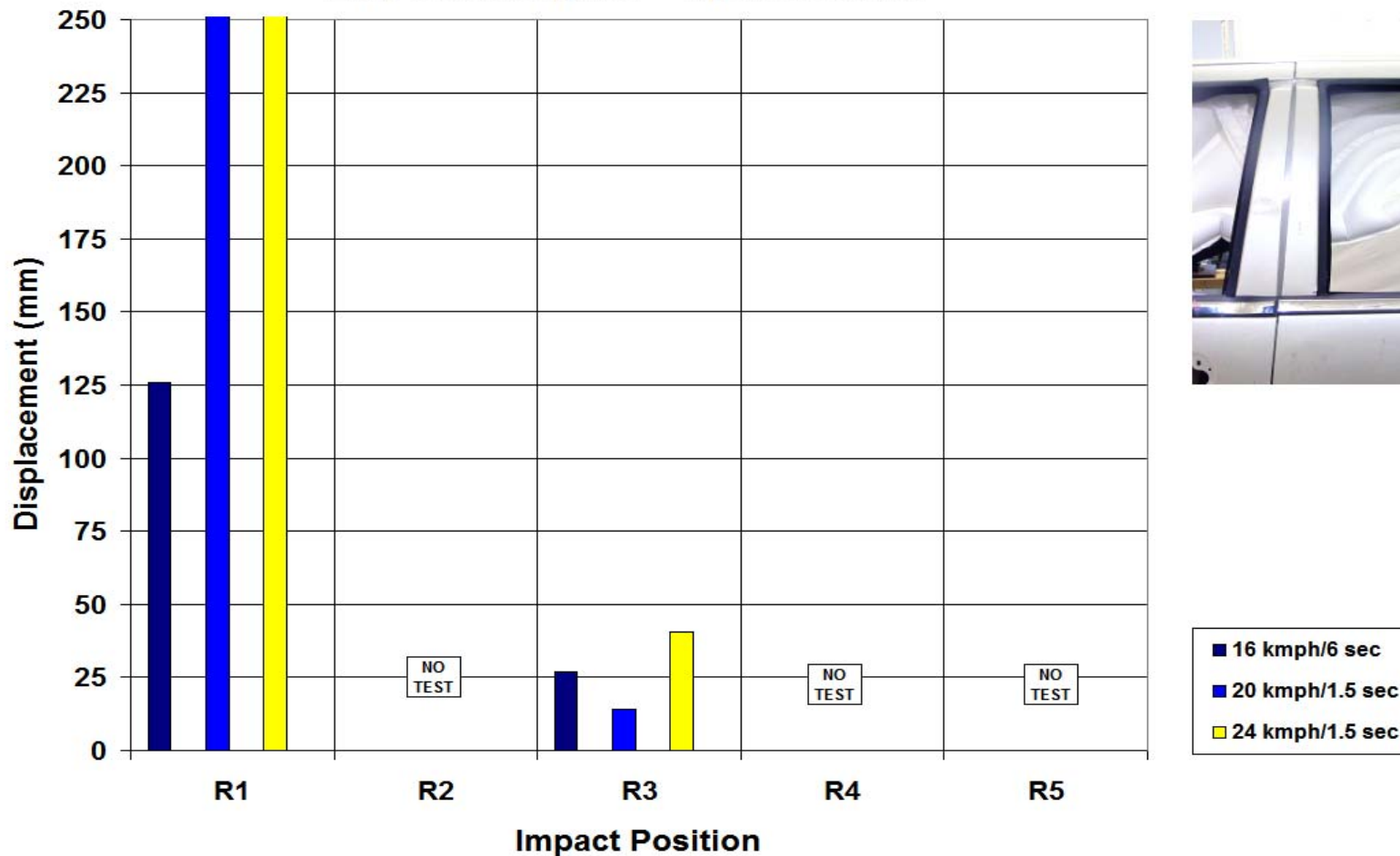
# Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane  
Zodiac AHPC - Open Window



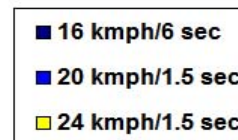
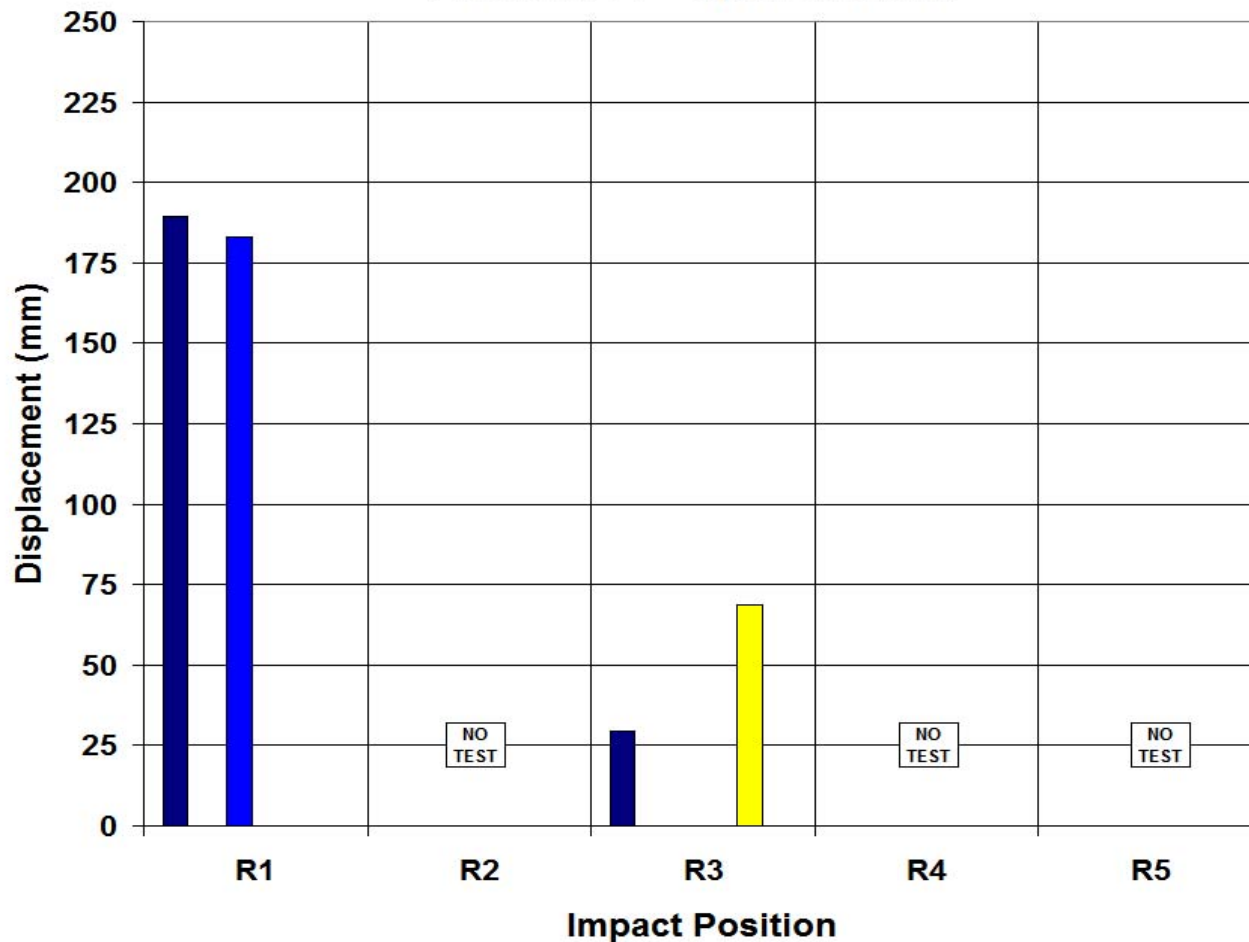
# Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane  
Lincoln Navigator - Open Window



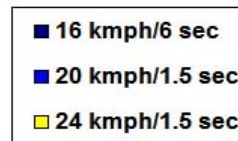
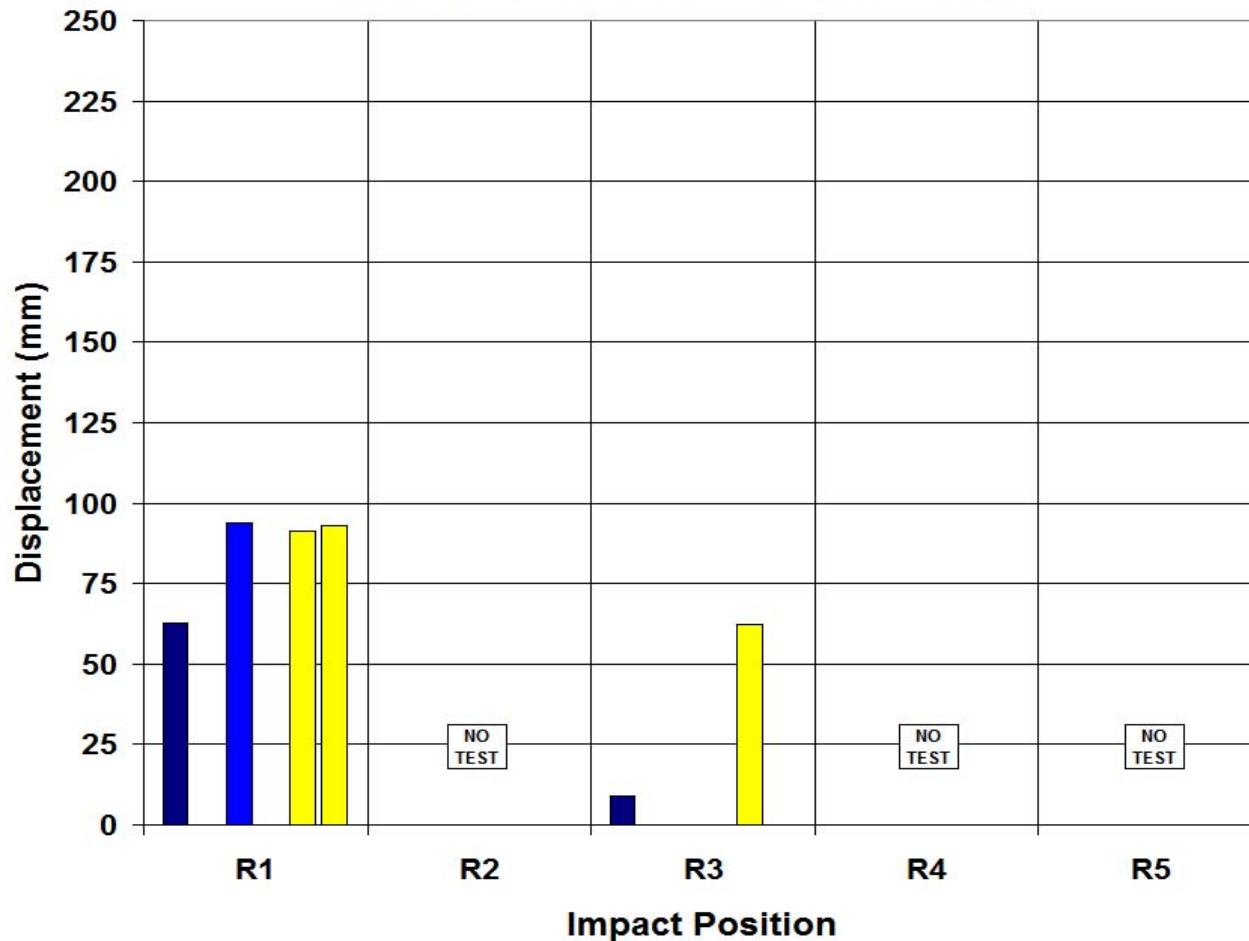
# Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane  
Volvo XC90 - Open Window



# Ejection Mitigation Impactor Results – Rear Window

**Maximum Excursion Beyond Window Plane  
Volvo XC90 - Pre-Broken Side Laminate**



# Ejection Mitigation

## Ongoing Research

- **Continue to Evaluate Current Production Systems**
  - Those that offer protection in rollovers
- **Develop or Adopt Method to Pre-Break Glazing**
- **Evaluate Possible Excursion Limit**
- **Develop Rollover Sensor Performance Test**

**THE END**